Research activities overview and future plans

Interview for the Post-doctoral Appointee position at the Argonne National Laboratory

Stefania Bordoni

24 April 2012

Education and qualification

2002 – 2005 : BSc in Physics
Università degli study di Bologna, Italy

2004 – 2005 : Erasmus year
Université Paris 7

2006 : Tesi di Laurea Triennale
Università degli study di Bologna, Italy

2007 : MSc in Physics,
Université Paris 7

2008 : Pre-doctoral studies in “NPAC – Nuclei, Astroparticle, Particles and Cosmology”, Université Paris 7

2011 : Ph.D in Particle Physics
Université Paris 6, (LPNHE Laboratory)

Research activities during the Ph.D.

Three major topics:

- **QCD background estimation for top-analysis**

Monte Carlo study of isolated leptons in multi-jet events (ATL-PHYS-INT-2010-011)

- **Systematics on the LAr calorimeters cells energy reconstruction**

Effect of electronic calibration constant variations on reconstructed cells energy in the ATLAS electromagnetic calorimeter (ATL-LARG-INT-2011-001)

- **Inclusive electron studies with the first data recorded by ATLAS**

Observation of inclusive electrons in the ATLAS experiment at $\sqrt{s}$ = 7 TeV (ATL-CONF- 2010-73)

Measurement of the electron and muon cross-section in proton-proton collisions at $\sqrt{s}$ = 7 TeV with the ATLAS detector (Phys. Lett B 707 2012 438-458)

All topics focused on the electrons reconstruction and identification

Teaching activities during the Ph.D.

- **2008 – 2011 :** Teacher assistant on physics and informatics for BSc students , Université Paris 7
- **2008 - 2009 :** Teacher assistant for International Masterclasses, LPNHE Paris
- **Nov. 2011 :** Teacher for a mini-course of introduction on data analysis with the ATLAS detector, Universitas de Los Andes, Mérida (Ve)

IT and programming skills

Systems :	Linux, Mac Os-X, MS Windows
Programming:	C++, Java
Data Analysis:	ROOT, GRID applications, TMVA, Mathematica, MathLab
Typesettings:	Latex
Productivity:	MS Office (PowerPoint, Word, Excell) , OpenOffice

Overview:

1) Overview of the research topics:

- Monte Carlo study of isolated leptons in multi-jet events
- Inclusive electrons studies
- Effect of electronic calibration constant variations on reconstructed cells energy

2) Future plans

Monte Carlo study of isolated leptons in multi-jet events

Motivation

- At the LHC one of the main potential background for many physics analysis (ttbar, SUSY, …) is due to QCD multi-jet events

- The rejection of this background relies mainly in the requirement of an isolated high-pT lepton on the event

- QCD events can however pass the signal selection cuts either by jets faking a lepton or by the semileptonic decay of heavy flavour quarks

Extra-lepton : isolated leptons reconstructed in topologies where no prompt leptons of that flavour are expected (i.e. electrons in ttbar semileptonic (μ) or in fully hadronic channels, di-jets events...)

Overview of the study

Aim :

- Get an handle on the QCD background
- To have a rough estimation of the extra-leptons rate by studying the kinematic characteristics of jets producing those extra-leptons

Strategy:

- Study of the extra-leptons origin and of the kinematics characteristics of the associated jets on ttbar semileptonic channel (absence of a fully simulated QCD sample at that time)
- Extrapolation of the extra-lepton rate to different topologies (ttbar fully hadronic channel, di-jets)

Extra-electron per jet rate in ttbar(μ) events

origin	with isolation $\cdot 10^{-5}$	without isolation $\cdot 10^{-5}$
b-jet	108 ± 7	431 ± 14
light jet:	50 ± 4	132 ± 6

- Extra electrons come mainly from b-jets (semileptonic decay of b-quarks)
- Evidence of the importance of the isolation requirement to control the QCD background

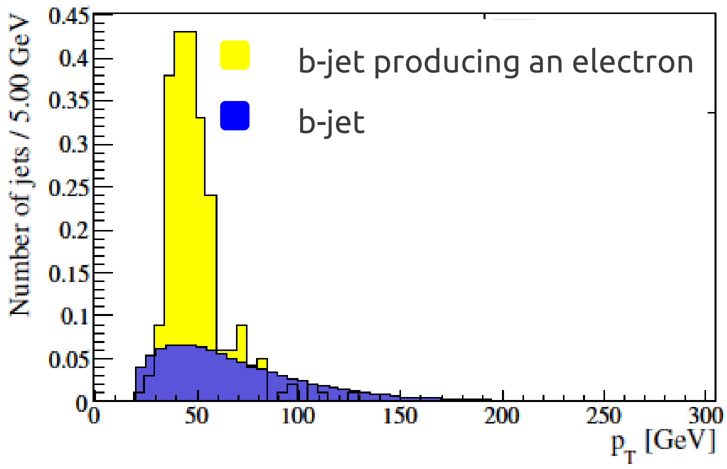
Prediction for other event topologies

- Determination of some characteristics behaviour of jets and extra-electron from the ttbar semileptonic samples
  - ✔ probability for a jet to produce an electron
  - ✔ expected spectrum of electrons produced by jets of a given energy
- Combination of those informations (considered as universal) with kinematics distributions retrieved from new event topologies (fully hadronic ttbar channel, di-jets)
- Determination of interesting distributions for new event topologies:
  - ✔ Expected spectrum of jets producing an extra-electron
  - ✔ Expected spectrum of extra-electron

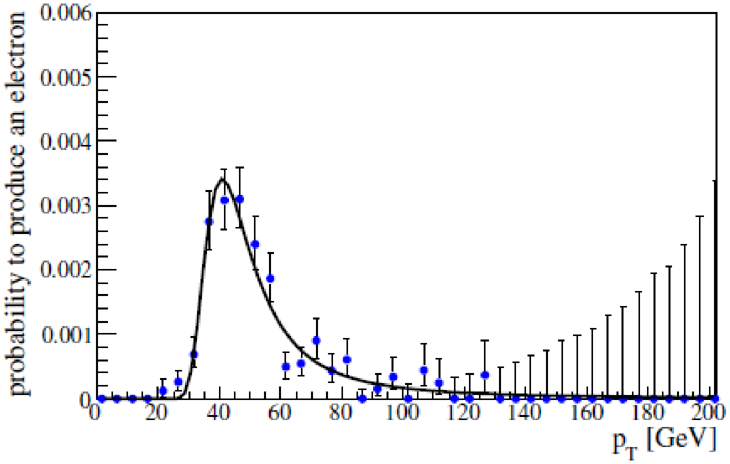
Probability for a jet to produce an extra-electron

Extraction of the probability distribution for a jet to produce an extra-electron from the jets kinematics distributions (ttbar semileptonic sample)

pT distribution of b-jets



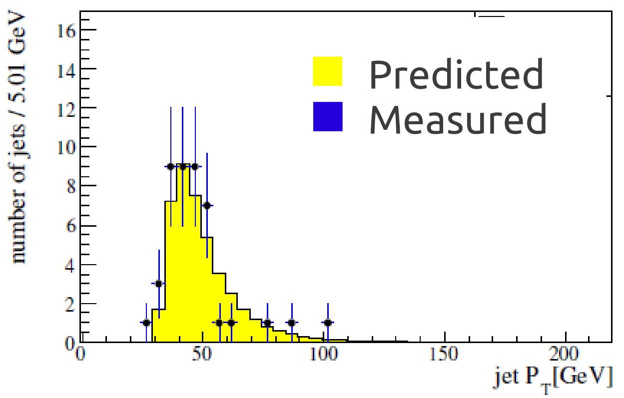
probability distribution for a b-jets to produce an electron



Extra-electrons predictions for multi-jet events

ttbar fully hadronic sample:

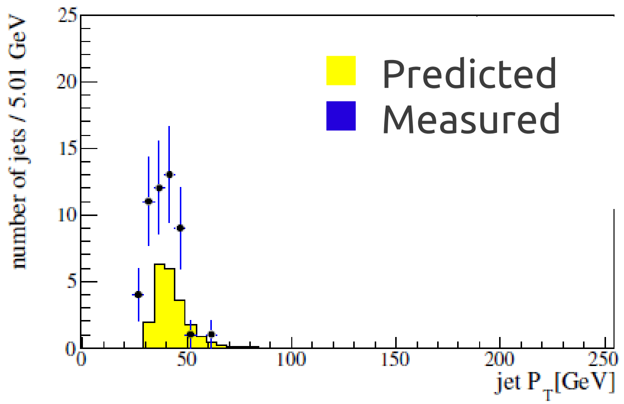
Jet producing an electron



Number of extra-electrons

parameters	from *b*-jet	from *light* jet	total
predicted	42^{+9}_{-6}	47^{+13}_{-12}	89^{+16}_{-13}
measured	44	36	80

Di-jet sample:



Number of extra-electrons

parameters	from *b*-jet	from *light* jet	total
predicted	21^{+6}_{-4}	364^{+153}_{-131}	385^{+153}_{-131}
measured	51	205	256

Conclusion

- Study of the extra-electrons origin and characteristics in high-pT multi-jets events to master the QCD background.
- Attempt to predict the extra-electrons rate by the study of the jets kinematics.
- The strategy pursued shows promising results when applied to ttbar fully hadronic channel, while not fully satisfactory results are obtained when the strategy is applied to a more different topology.

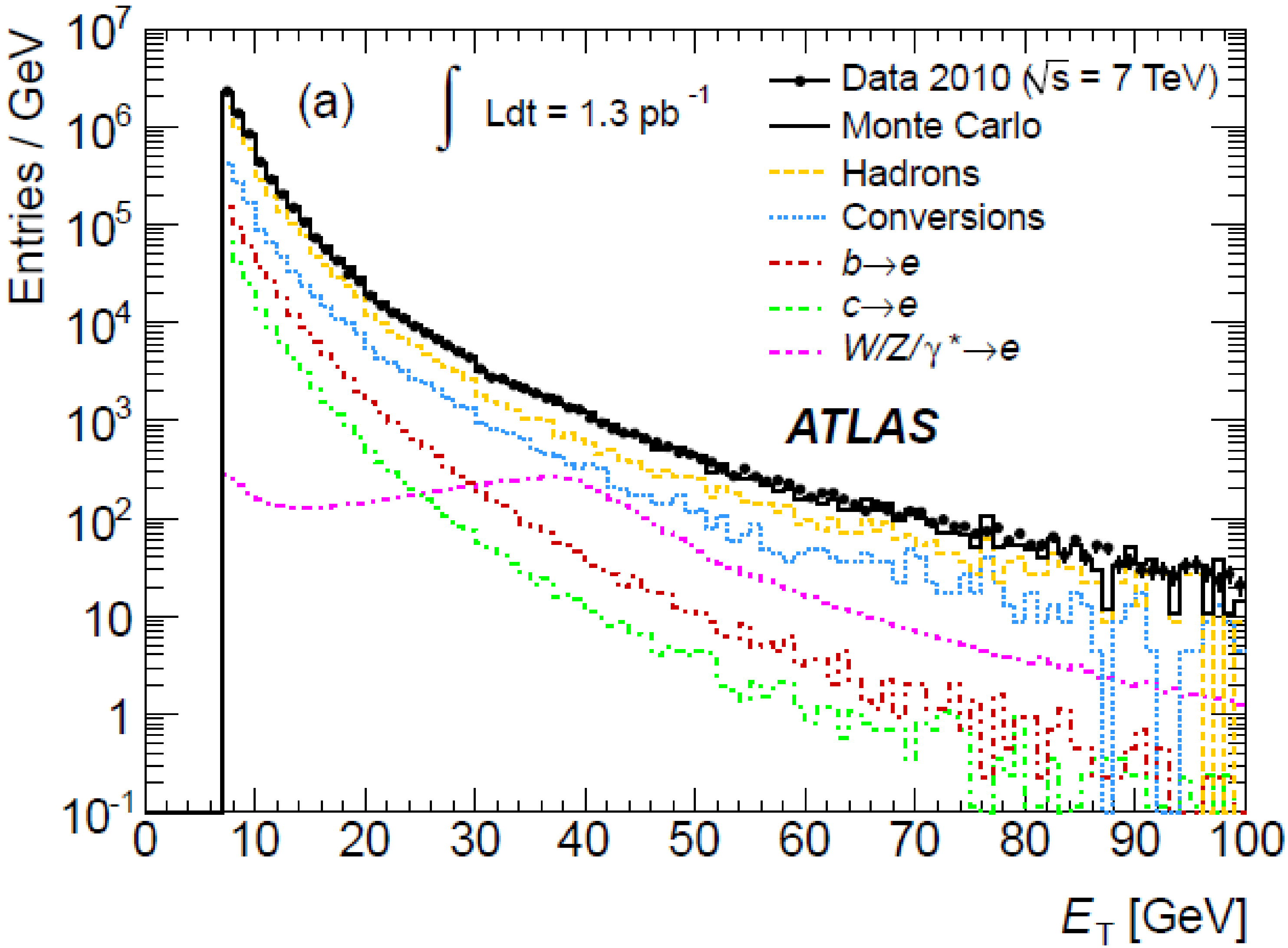
From this study : Collaboration within the top-egamma liaison group to optimize the electron isolation criteria wrt the QCD rejection rate

Inclusive electron studies
and
cross-section measurement of electrons coming from HF quarks decay

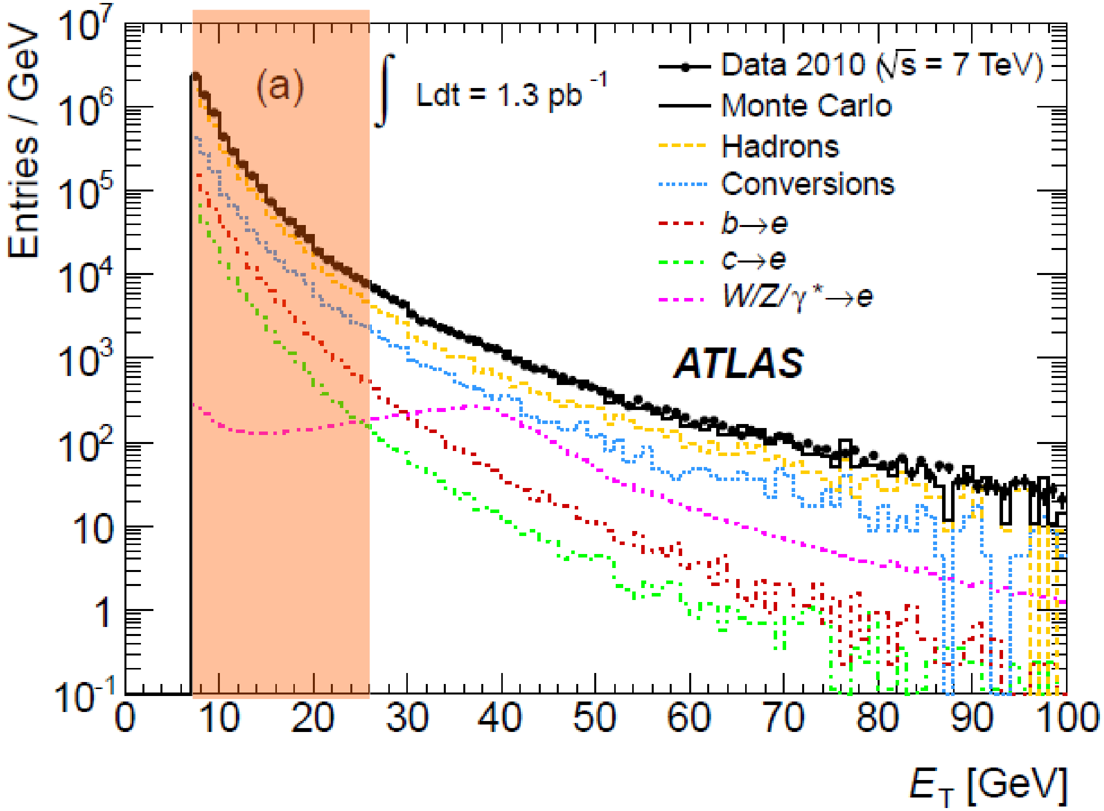
The analysis uses the first data sample recorded by ATLAS (April – August 2010)

$\mathcal{L} = 1.28 \pm 0.04\ \mathrm{pb}^{-1}$

The Inclusive electron spectra



The Inclusive electron spectra



In the high energy region the isolated electrons from W, Z, γ* dominate against electrons from heavy flavour (HF) decays.

→ To measure the $\sigma_{b,c \to e}$ the analysis range is restricted to 7 – 26 GeV

Motivation

Experimental motivations:

- The understanding of the electrons production on proton proton collisions is a pre-requisite for measurements and searches having these particles in the final state
- At low pT the measurement of the inclusive electrons cross-section can be used to constraint theoretical predictions for heavy-flavour quark production

Theoretical motivations:

- During the past 15 years measurements of b-quark productions in hadronic environment have been a challenging domain because of a disagreement observed between data/theory
- The disagreement was solved improving both data analysis and theoretical calculations
- The HF production cross-section measurement performed at the LHC can probe the effect of the NLL resummation in pQCD calculations

The cross-section measurement

The fiducial differential cross-section is given by:

$$\boxed{\frac{\Delta\sigma}{\Delta p_{\mathrm{T}}} = \left(\frac{N^{\mathrm{Q}\rightarrow\mathrm{e}}}{\epsilon_{\mathrm{trigger}} \cdot \int \mathcal{L}\mathrm{d}t} - \sigma^{\mathrm{W/Z}/\gamma^*}_{\mathrm{accepted}}\right) \cdot \frac{C_{\mathrm{migration}}}{\epsilon_{\mathrm{reco+ID}}} \cdot \frac{1}{\Gamma_{\mathrm{bin}}}}$$

$N^{Q\rightarrow e}$: number of HF signal electrons extracted in a bin of width Γ_{bin}

$\sigma^{W/Z/\gamma*}$: isolated electron contribution subtracted to the performed measurement (the extracted signal contains a small contribution from isolated electrons)

$C_{\mathrm{migration}}$: correction factor to account for bin by bin migration in unfolding

→ In the following slide I will focus on the signal extraction ($N^{Q\rightarrow e}$) and on the measurement of the identification efficiency

Electron candidate selection

- The selection criteria are based on the official egamma flags (Medium electrons)
- A tuning of the criteria is done to optimize the selection wrt HF electrons (against hadron and conversion background)
- The applied preselection and identification criteria leads to :

  - 70 % hadrons
  - 20 % conversions
  - 10 % signal

N.B.

The signal fraction can be increased up to 50% applying tighter criteria based on variables (TRfrac, nBL, eoverp) with a good discriminating power against hadrons .

This is not done for the analysis to be able to use these variables to estimate the background component from data.

Background subtraction

Extraction of HF electrons ($N^{Q\rightarrow e}$) in a given E_T bins from background (hadrons and conversions) using a likelihood method based on :

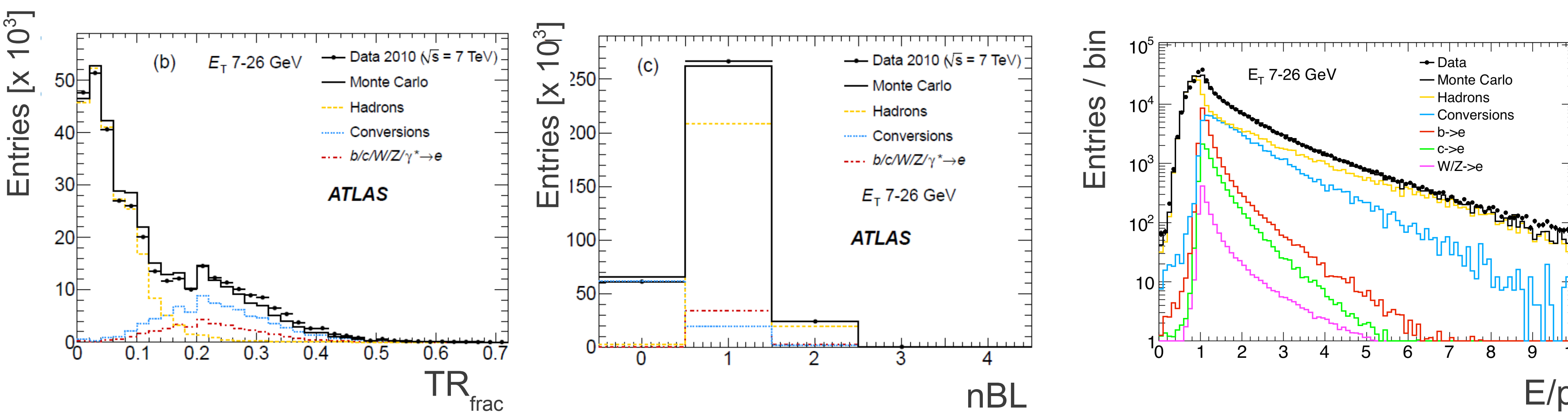
TRfrac : fraction of high threshold TRT hits

→ Strong discrimination against hadrons

nBL : number of B-layer hits

→ Strong discrimination against conversions

E/p : ratio of cluster energy to track momentum



Identification efficiency

- The identification efficiency considered for the cross-section measurement is extracted from the simulation
- A data driven approach is performed to check the ID efficiency on data
- The Tag and Probe technique is applied to bbar events
    - A tight selection is applied to the tag electron to enrich the probe sample with signal HF electrons
    - The probe sample is still dominated by the background components
    - Extraction of the signal component by the likelihood method before (N^{Q}_{probe}) and after ($N^{q}_{probe\&ID}$) the application of the identification criteria

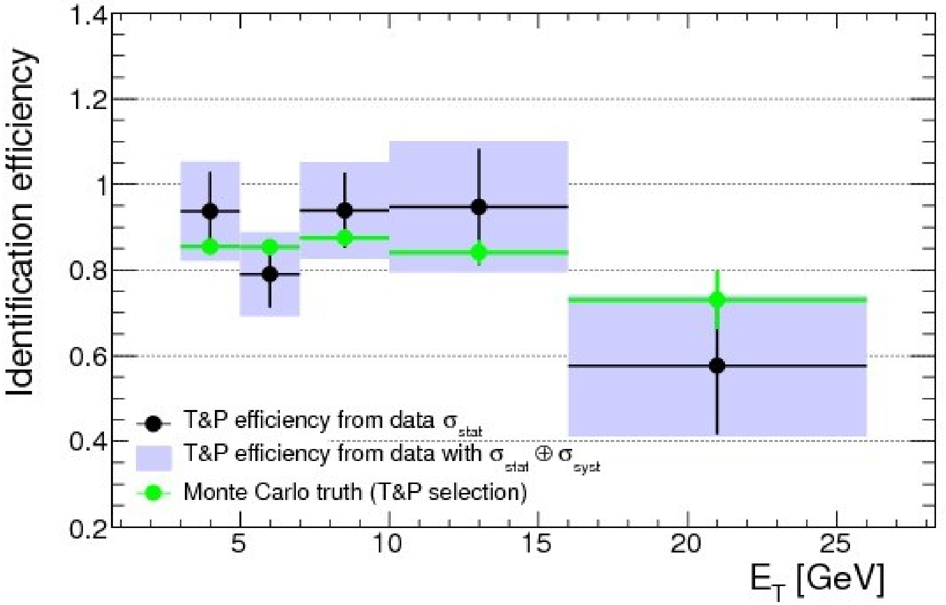
	probe electron	probe & identified electrons
Misidentified hadrons (%)	73.7	49.3
Electrons from conversions (%)	17.3	19.5
Signal electrons (%)	9.0	31.2

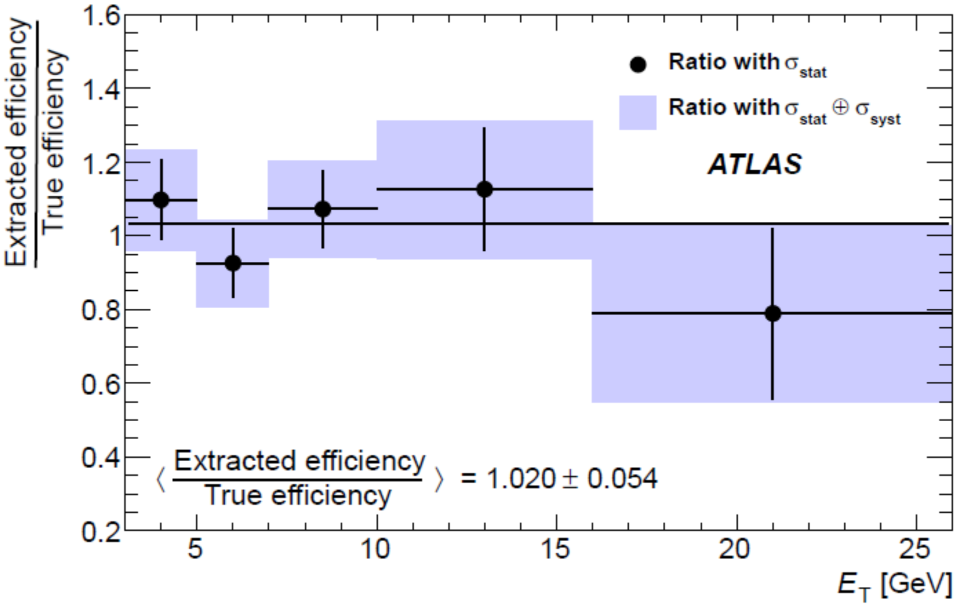
Signal identification efficiency using T&P

$$\epsilon_{\mathrm{ID}}^{\mathrm{T\&P}} = \frac{N_{\mathrm{probe\ \&\ identified}}^{Q\to e}}{N_{\mathrm{probe}}^{Q\to e}}$$

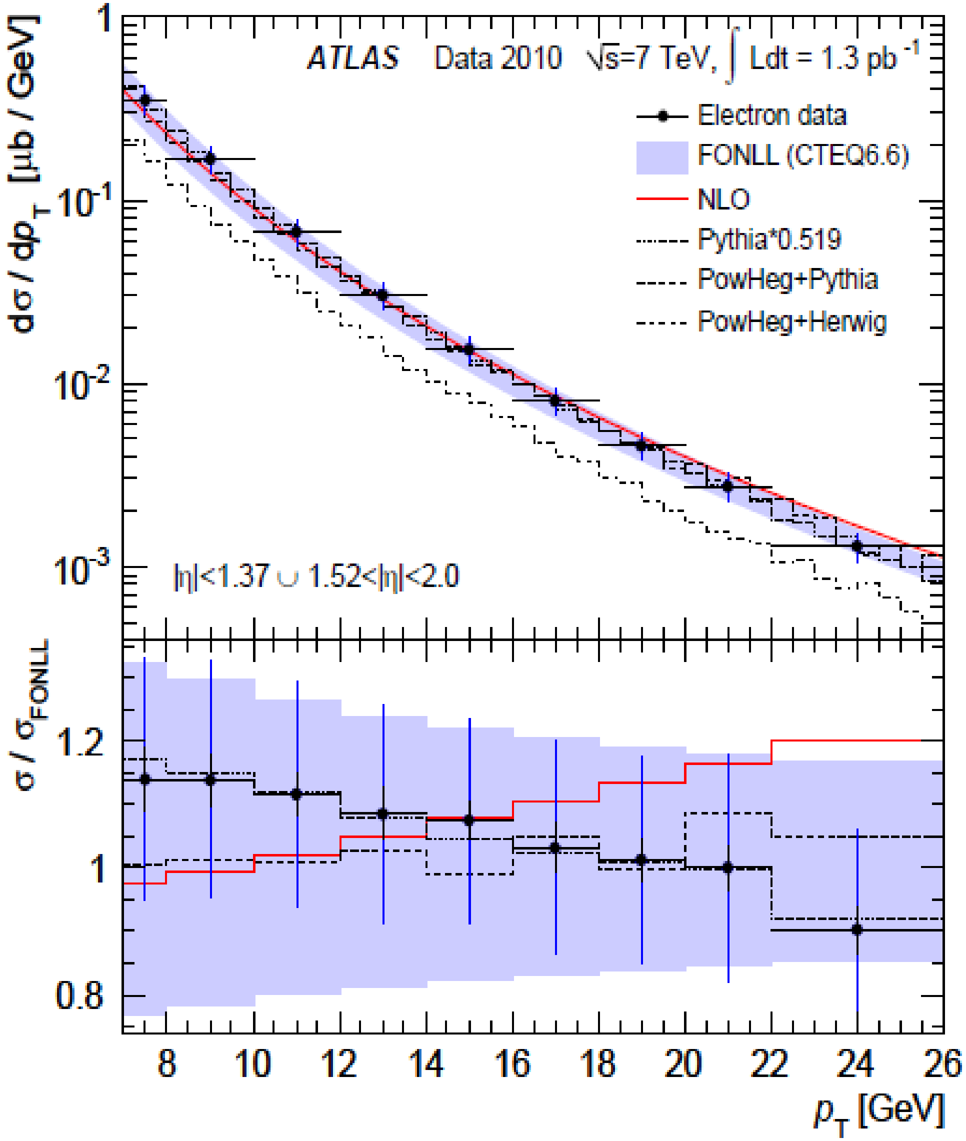
- Because of the statistics available, the extracted data-driven efficiency cannot be used directly bin by bin in pT for the cross section measurement.

- The measurement is used to estimate the scale factor to correct the MC based efficiency estimation.





The $\sigma_{b,c \rightarrow e}$ measurement



The systematic uncertainties

Source of uncertainty	$\mathrm{TR_{frac}}$, nBL, E/p
Statistical error on extracted signal	2.7–4.3%
Possible bias of the method :	
Electron signal extraction (correlation in $h \to e$)	7.3%
Efficiency measurement	3.8%
Mismodelling of discriminating variables :	
$TRfrac$ (*)	4.5%
n_{BL} (*)	5.6%
E/p	3.2%
f_1 (*)	2.8%
Energy scale (*)	1.5%
Efficiency dependence on p_T from T&P	5.4%
Material uncertainty on $\epsilon_{\mathrm{reco+ID}}/C_{\mathrm{migration}}$	4.8–9.7%
MC statistical error on $\epsilon_{\mathrm{reco+ID}}/C_{\mathrm{migration}}$	0.4–3.5%
MC statistical error on templates for signal extraction	0.8–2.5%
Luminosity	3.4%
Trigger efficiency (stat+syst)	$< 2\%$
Accepted Drell-Yan cross-section (MC stat+syst)	$< 1\%$
Total	15–18%

Conclusion

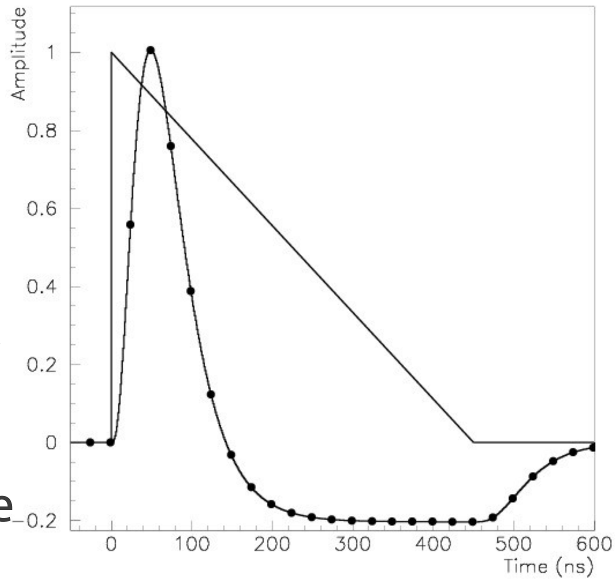
- The measurement of the differential cross-section of electrons from heavy flavour quarks decay has been measured (7 < ET < 26 GeV)
- A tuning of the standard identification flags for electrons identification has been performed
- The electron cross-section measurement is fully compatible with FONLL and NLO predictions
- An analogue measurement has been performed on muon channel: fully compatible with the electron cross-section
- The inclusive differential muon production has been extended to the high energy region and a deviation is observed from the NLO central prediction → sensitivity of the heavy flavour production to the NLL high-pT resummation terms (FONLL)

Systematics on the cell reconstructed energy of the LAr EM-calorimeter

Overview

Aim:
Quantify the bias on the reconstructed cell energies related to the typical variations of the electronic calibration constants

- Energy is proportional to the signal amplitude
- Calibration: injection of a pulse of a known amplitude on each cell and reconstruction of the energy
- Passing trough the readout chain signals are shaped, amplified and digitized
- Each characteristic of the shaped signal is parametrized by an electronic calibration constant
- Specific calibration runs are regularly taken to monitor the electronic calibration constants values.
- Typical variations of the calibration constants are of the order of few per mill → the database is not updated



The cell energy reconstruction

$$E_{\mathrm{cell}} = F_{\mu\mathrm{A}\to\mathrm{MeV}} \cdot F_{DAC\to\mu\mathrm{A}} \cdot \frac{1}{\frac{\mathrm{M_{phys}}}{\mathrm{M_{cali}}}} \cdot R \left[\sum_{j=1}^{N_{\mathrm{samples}}} a_j \left(s_j - p \right) \right]$$

Pulse samples

ADC to DAC (Ramps)

Cell energy

Charge to E conversion

Calibration board

Optimal Filtering Coefficients

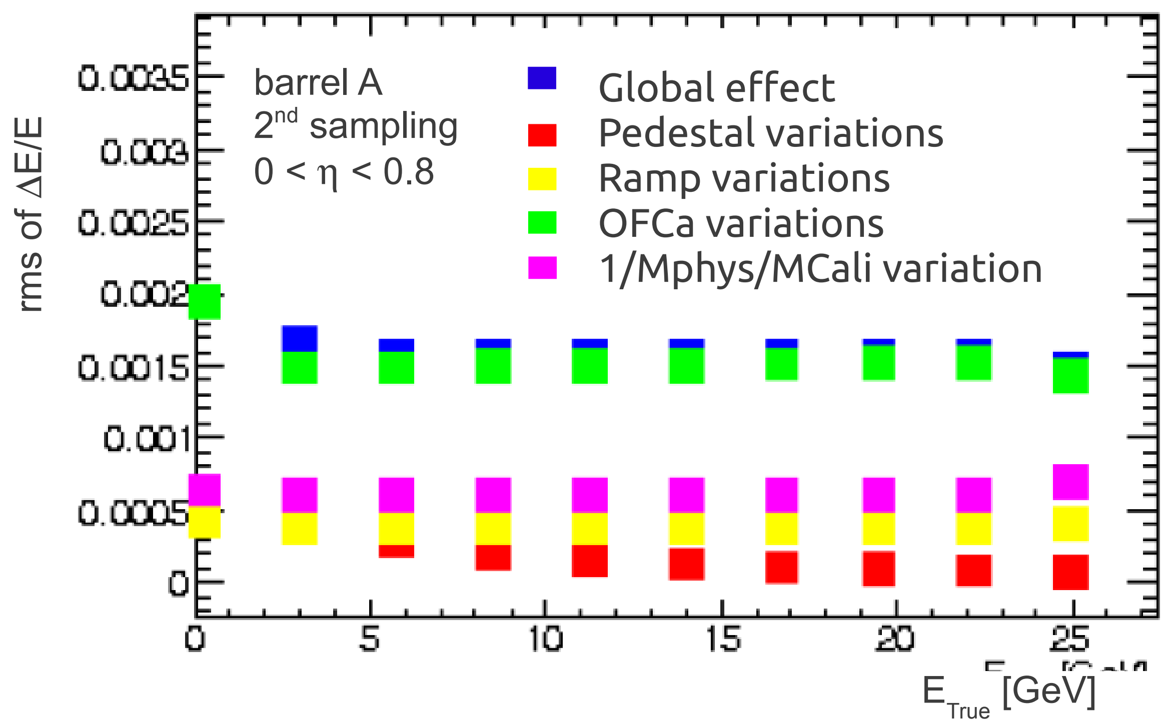
Pedestals

Signal amplitude

- Several steps are needed to reconstruct the cell energy from the electronic signal (from ADC counts to MeV units)
- The cell energy is proportional to the signal amplitude
- The calibration and ionization pulse differences are taken into account (M_{phys}/M_{Cali})

Effect of the LAr electronic calibration constants variation on the reconstructed cells energy

- Use of two calibration campaigns with typical variations of the electronic calibration constants
- Reconstruction of the cells energy with the two sets of calibration constants
- Estimation of the bias by comparing the two reconstructed energies
  - ✔ change of the full set of constants → global effect
  - ✔ change of one constant per time → simple effect



Conclusion

- The study allowed to quantify for the first time the effect of the variations of the electronic calibration constants on the cells reconstructed energy
- The bias is estimated at very few per mills for 90% of the tested cells (EMB-A)
- The updating procedure of the constant database is confirmed because the bias is found negligible as expected

Future Plans

Future Plans

With the 8 TeV proton-proton collisions, the year 2012 promise to be a very intense, challenging and exciting year

- Test of the SM at very high energies
- Higgs searches
- Searches for hint of new physics

(i.e. particle produced beyond the TeV scale energies)

- Many interesting topics are currently curried on within your group
- Looking forward to the LHC plans (14 TeV runs, High Luminosity programs) my attention is addressed to the searches for BSM physics.

Future plans: analysis

Top-quarks pairs production studies in a boosted regime are very interesting and challenging analysis:

- Characteristic topologies for boosted ttbar events (different from those presented by top-quarks pairs produced at rest)
- Performances and efficiencies of the standard reconstruction and identification algorithms are not know for objects with pT= O(TeV)
- A redefinition of some selection criteria (e.g. lepton isolation) can be necessary to fully exploit the discovery potential of these boosted states

Future plans: analysis

Some ideas to start a contribution to these analysis:

- Deep knowledge of the LAr Calorimeters

  → electromagnetic shower shape variables can add interesting informations for high pT jets substructure

- Acquired experience on electron reconstruction and identification

  → tuning the standard electrons identification criteria

  → study for a new definition of the isolation criteria

- Expertise on electrons coming from quarks heavy flavour decays

  → contribute to the jet b-tagging

Ready to contribute actively to different aspects of the analysis

✔ responsibilities roles

✔ Combined Perfomances group

✔ Liaison group (as the new top-boosted liaison group)

Future plans: detector activities

Detector activities :

- fine comprehension of the detector performances
- good master of the discriminating power offered by the ATLAS subdetectors

Strong motivation for contributing to current and upgrade detector activities

- Trigger : improve my understanding of the ATLAS detector .
- Fast Tracker upgrades issues : extend my expertise on hardware activities

Back up

Extra-electron study

	# events	# jets	# extra-leptons	# extra-lepton/ jet
ttbar (μ) :	~96,000	526,142	544	103 ± 4
ttbar (e) :	~124,000	548,009	630	115 ± 5

Extra-electrons classification according to the egamma prescription:

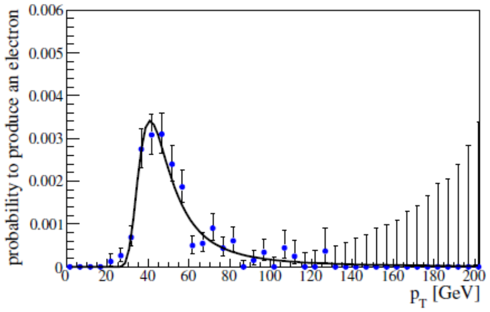
- *Non prompt:* reconstructed electron matching a true electron (isolated, non- isolated, from bkg processes)
- *Fake :* mis-reconstructed object (jet, muons, ..)

extra electron origin				
	with isolation requirement		*without isolation requirement*	
excluded electrons (dR>1)	-		2	
origin	*non-prompt*	*fake*	*non-prompt*	*fake*
b-jet	223	8	838	80
light jet	42	115	88	325
overall	265	123	926	405

Prediction for other event topologies

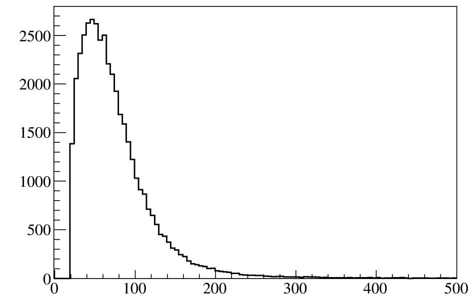
1) Spectrum of jets producing an electron

(pT)Probability distribution
(ttbar semileptonic)



X

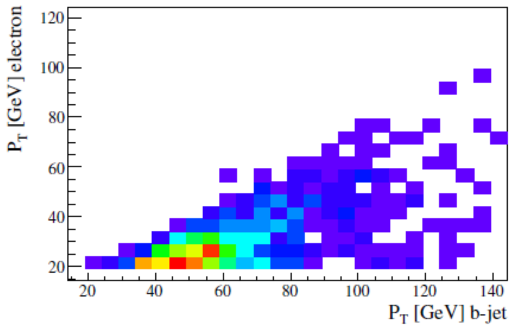
jet pT spectrum
(of a new event topology)



pT [Gev]

2) Extra electron number and spectrum

Scatter plot: jet pT vs el_pT
(ttbar semileptonic)



Determination of the spectrum of electrons produced by a jets of a given energy (projection the Y-axis of the scatter plot)
Combination with the jet spectrum obtained from 1)

The FEB electronic readout of the EMCal

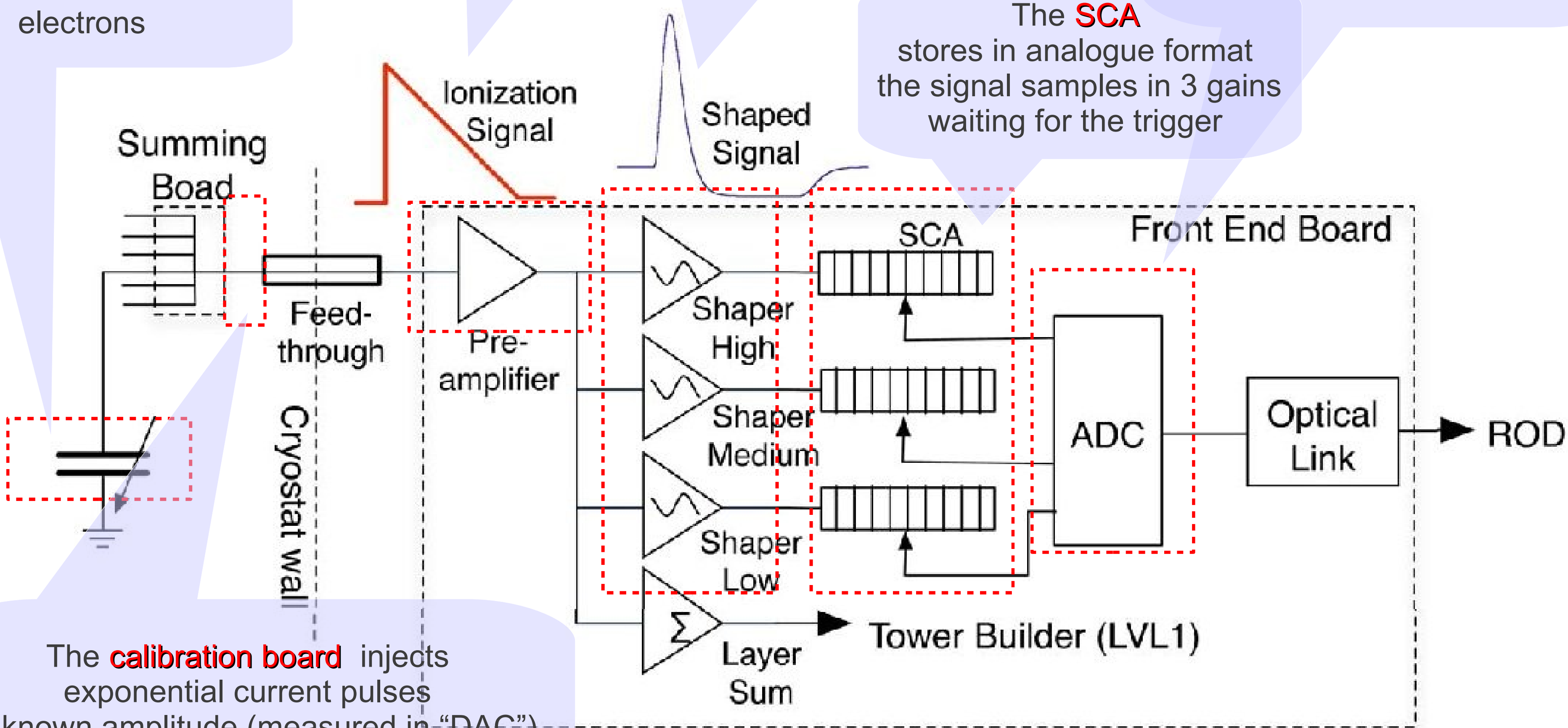
The **LAr cell electrodes** collect the LAr ionization electrons

The **preamplifier** amplify and integrates the current signal

The **shaping filter** shapes the amplified signal in 3 gains (HIGH, MEDIUM, LOW)

Once the trigger say "yes!" the selected samples are digitized by th **ADC** and transmitted to the back-end electronics

The **SCA** stores in analogue format the signal samples in 3 gains waiting for the trigger



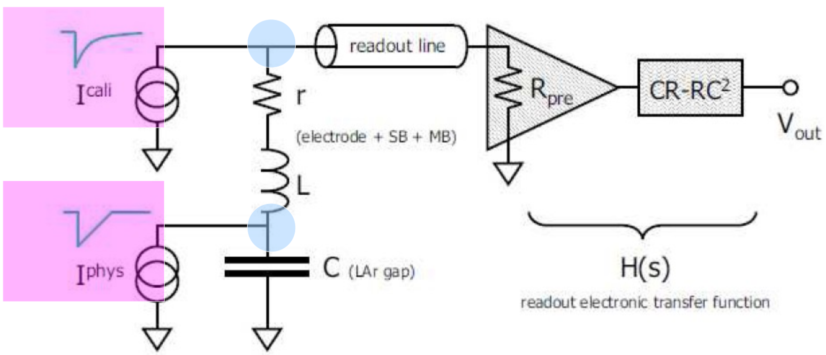
The **calibration board** injects exponential current pulses of known amplitude (measured in "DAC") on the detector cell, to probe the actual electronic response

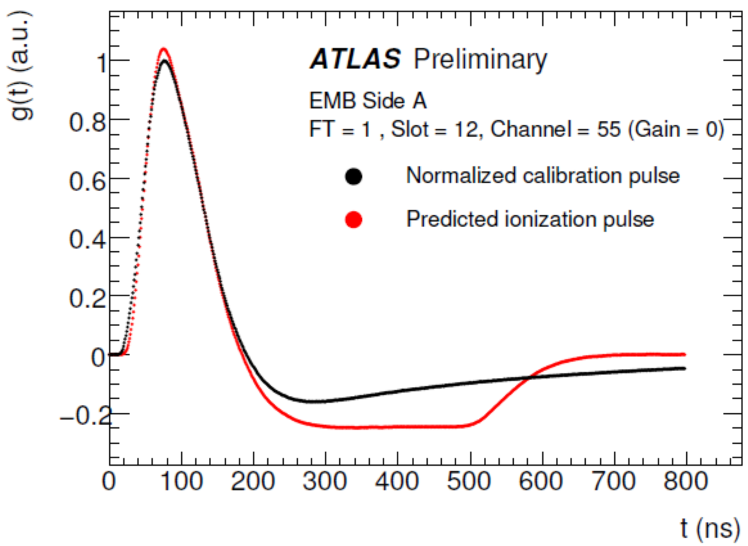
Calibration *Vs* physics pulses

Calibration → injection of a pulse of a known amplitude in each calorimeter cell and reconstruction of the energy through the full procedure.

The calibration differs from the ionization pulse for :

- the shape
- the injection point





Prediction of the ionization signal from the calibration pulse by the *Response Transformation Method (RTM)* → few parameters reflecting the detector's geometry and the calibration pulse properties

The FEB electronic readout of the EMCal

$$\underbrace{E_{\text{cell}}}_{\text{Cell energy}} = \underbrace{F_{\mu\text{A}\to\text{MeV}}}_{\text{Charge to E conversion}} \cdot \underbrace{F_{DAC\to\mu\text{A}}}_{\text{Calibration board}} \cdot \frac{1}{\frac{\text{M}_{\text{phys}}}{\text{M}_{\text{cali}}}} \cdot \overbrace{R}^{\text{ADC to DAC (Ramps)}} \left[\sum_{j=1}^{N_{\text{samples}}} \underbrace{a_j}_{\text{Optimal Filtering Coefficients}} \left(\overbrace{s_j}^{\text{Pulse Samples}} - \underbrace{p}_{\text{Pedestals}} \right) \right]$$

- ***p*** **:** pedestal measuring the baseline signal of the cell (in ADC counts);
- s_j **:** signal samples (in ADC counts) ;
- a_j **:** optimal filtering coefficients to compute the signal amplitude;
- ***R*** *:* ramp factor giving the linear conversion between ADC to DAC units;
- $1/(M_{phys}/M_{cali})$: correction factor taking into account the differences between the calibration and the ionization pulse;
- $F_{DAC\to\mu A}$: converting factor from arbitrary units (DAC) to current units (µA);
- $F_{\mu A\to MeV}$: converting factor from current units (µA) to energy units (MeV).

Effect of the LAr electronic calibration constants variation on the reconstructed cells energy

Systematic uncertainty on the cell reconstructed energy for each layer:

- Mean → systematic deviation of the calorimeter working point
- Width → systematic bias affecting the cells reconstructed energy

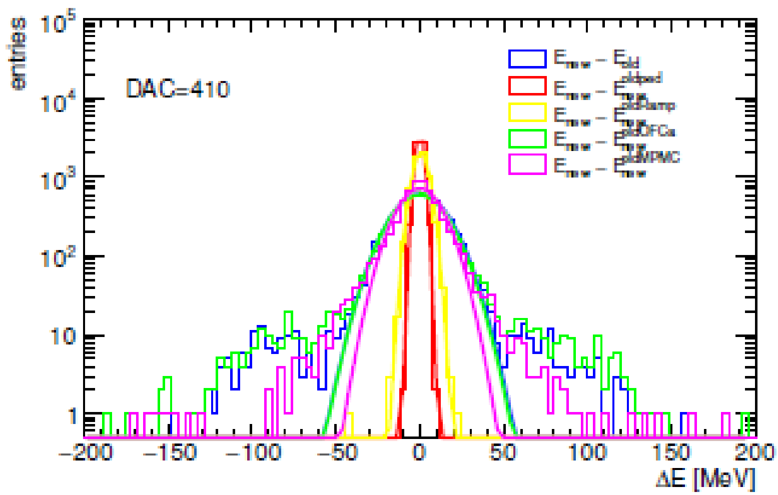
Relative errors of the cells reconstructed energies

		front $\eta < 0.8$	front $\eta \geq 0.8$	middle $\eta < 0.8$	middle $\eta \geq 0.8$	back $\eta < 0.8$	back $\eta \geq 0.8$
included fraction in 2σ		96%	90%	94%	92%	88%	88%
$OFCa^{Phys}$ variation	mean	0.01‰	-0.04‰	-0.07‰	-0.03‰	-0.05‰	-0.07‰
	widths	2.3‰	2.3‰	1.5‰	0.9‰	1.4‰	1.3‰
$\frac{1}{M_{Phys}/M_{Cal}}$ variation	mean	0.02‰	0.06‰	0.03‰	-0.01‰	0.05‰	-0.02‰
	widths	0.9‰	1.1‰	0.6‰	0.7‰	0.5‰	0.5‰
global effect	mean	0.08‰	0.06‰	-0.06‰	<0.01‰	0.04‰	-0.08‰
	widths	2.2‰	1.8‰	1.6‰	0.9‰	1.4‰	1.3‰

The systematic uncertainty is estimated at few per mill for 90% of the cells of the EMB-A (barrel, A side).

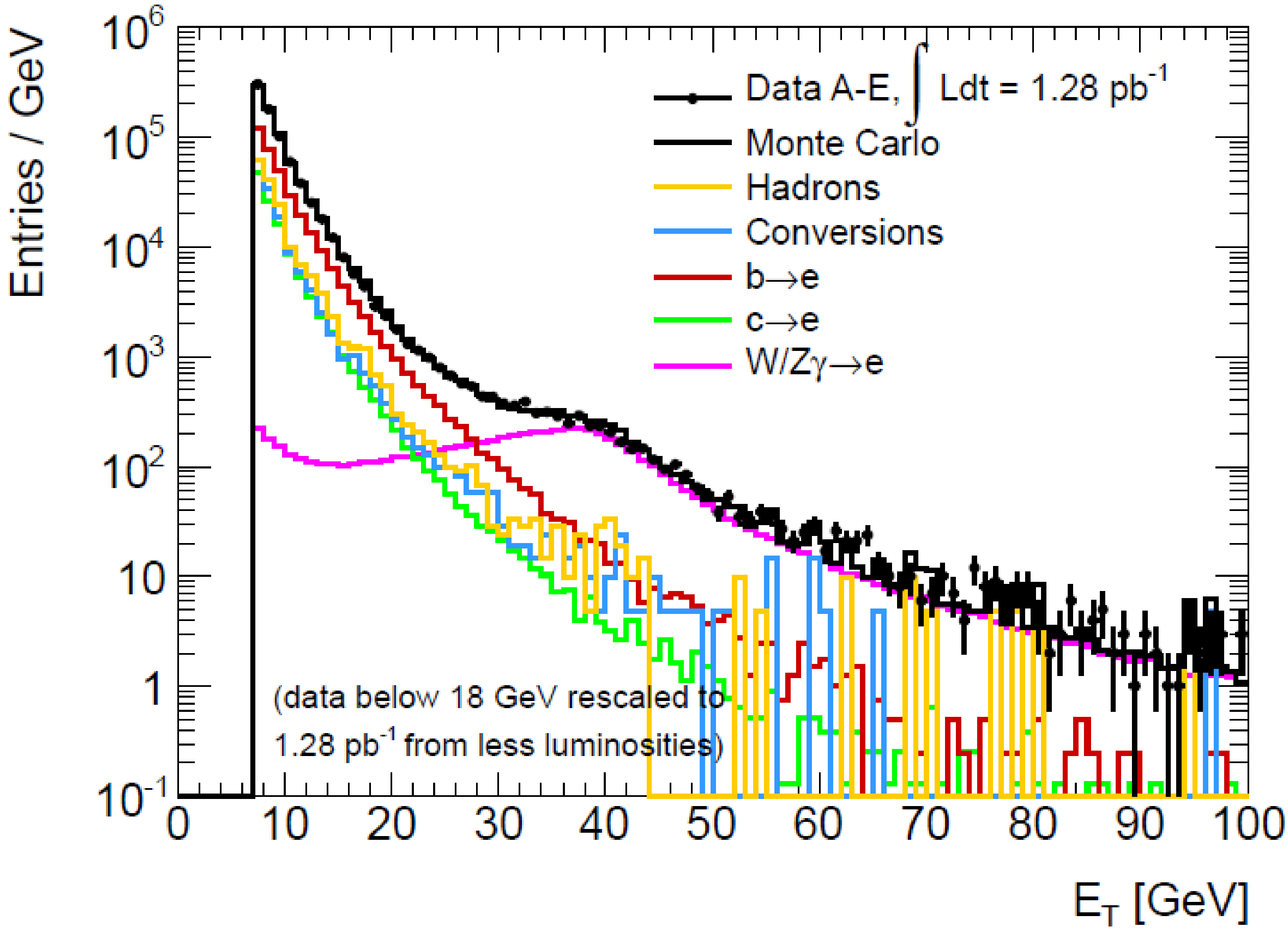
Study of the non-Gaussian effects

- Observation of non-Gaussian effects for ~ 10% of the cells for each layer;
- The systematic error is estimated by a very conservative approach ;
- The location of the cells populating the non-Gaussian tails seems to indicate a larger inaccuracy of the prediction of the ionization pulse in these regions.



Relative errors on the reconstructed energies						
	front		**middle**		**back**	
	$\eta < 0.8$	$\eta \geq 0.8$	$\eta < 0.8$	$\eta \geq 0.8$	$\eta < 0.8$	$\eta \geq 0.8$
included fraction of cells	4%	10%	6%	8%	12%	12%
error	1.5%	2%	0.7%	0.9%	1.5%	1.7%

Inclusive electron spectrum with tight criteria



Details of the electron selection criteria

Electron selection based on the official egamma "Medium-electron" flag BUT without applying hadronic leakage and R_η criteria

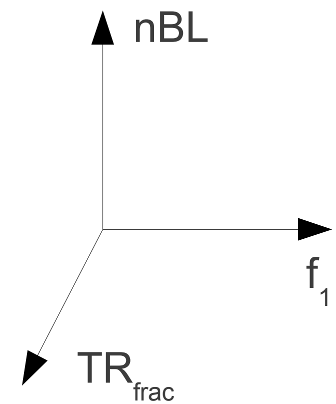
Type	Description	Name
	Acceptance	
Fiducial cuts	$\|\eta\| < 2.0$ ($1.37 < \|\eta\| < 1.52$ excluded)	-
	$E_T > 7, 10, 14$ or 18 GeV depending on period	-
	Preselection cuts	
Fiducial cuts	Remove candidates with clusters near problematic regions in EM calorimeter	-
	Remove candidates with tracks passing through dead B-layer modules	-
Tracking cuts	At least 10 TRT and 4 silicon hits	-
Strip layer of the EM calorimeter	Fraction of the raw energy deposited in the strip layer (> 0.1)	f_1
	Identification cuts (in addition to the preselection cuts)	
Strip layer of the EM calorimeter	Total lateral shower width (20 strips)	w_{stot}
	Ratio of the energy difference between the largest and second largest energy deposits over the sum of these energies	E_{ratio}
Middle layer of the EM calorimeter	Lateral width of the shower	w_2
Track quality	Number of hits in the pixel detector (at least one)	-
	Number of hits in the pixels and SCT (at least seven)	-
	Transverse impact parameter (< 1 mm)	d_0
Track matching	$\Delta\eta$ between the cluster and the track (< 0.01)	$\Delta\eta_1$

76 % hadrons
22 % conversions
2 % signal

70 % hadrons
20 % conversions
10 % signal

Background subtraction: the *Tiles Method*

- A three dimensional space is built using the discriminating variables (f_1, nBL, TR_{frac})



- The number of expected electrons in each tile (tile = bin) of the space can be estimated in terms of probabilities (pdfs):

$$N(i) = N^{Q\to e} P^{Q\to e}(i) + N^{\gamma\to e} P^{\gamma\to e}(i) + N^{h\to e} P^{h\to e}(i)$$

Number of electrons for each component of the spectra:
to be determined !

Probability (pdf) for an electron of the contribution (Q → e, g → e or h → e) to belong to the tile i

A log-likelihood function is built allowing to determine $N^{Q\to e}$, $N^{\gamma\to e}$, $N^{h\to e}$

$$\boxed{- \ln L(N^{Q\to e}, N^{\gamma\to e}, N^{h\to e}) = \sum_i N(i) - N_{obs}(i) \ln N(i)}$$

Background subtraction: the *Tiles Method*

Some more details ...

$$N(i) = N^{Q\to e}\, p^{Q\to e}(i) + N^{\gamma\to e}\, p^{\gamma\to e}(i) + N^{h\to e}\, p^{h\to e}(i)$$

i) The probabilities are extracted from the simulation for the conversions ($p^{\gamma\to e}(i)$) and the signal ($p^{Q\to e}(i)$) components;

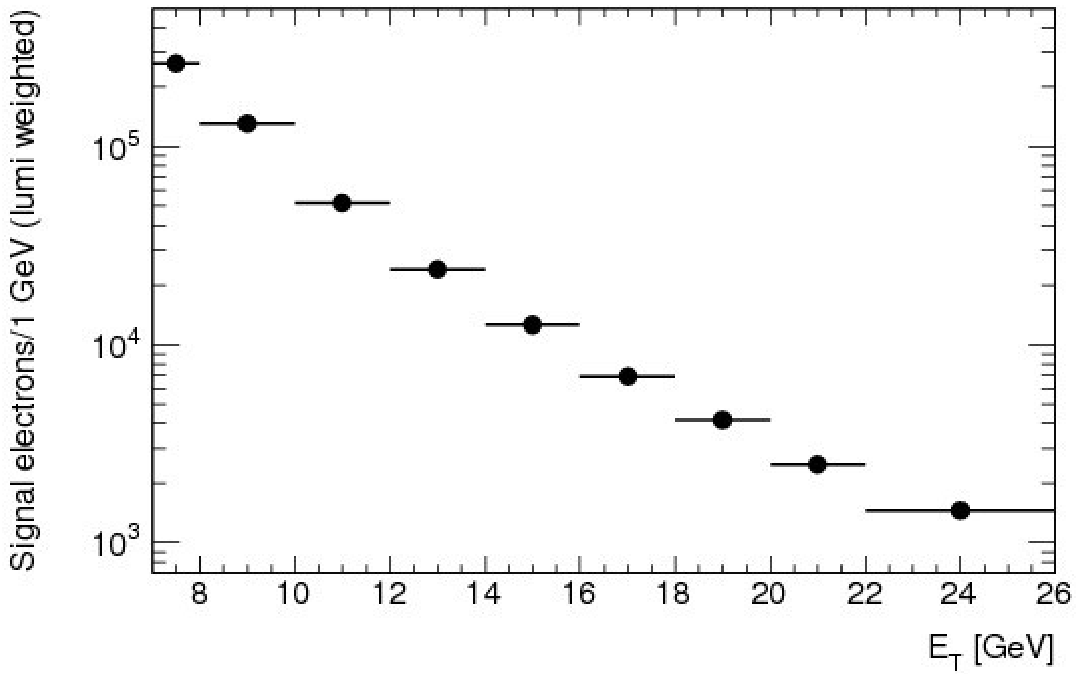
ii) The probabilities for the hadron component ($p^{h\to e}(i)$) are kept as free parameters of the fit because of the unsatisfactory description offered by the simulation;

iii) The unknown three dimensional pdf for the hadron component is assumed to be factorize in three one-dimensional pdf:

$$p_i^{h\to e}(TR_{frac}, nBL, f1) = p_i^{h\to e}(TR_{frac}) \times p_i^{h\to e}(nBL) \times p_i^{h\to e}(f_1).$$

The method applied in i) and the assumption made in ii) are considered as sources of possible systematics uncertainties.

N^{signal} estimation



For a luminosity of 1.3 pb^{-1}, for 409 190 selected electrons, the number of electrons from heavy flavour decays extracted is :

47 789 ± 1 583 (stat) ± 4 408 (syst)

$$\sigma = \frac{N^{signal}}{\epsilon \cdot \mathcal{L}}$$

The unfolding procedure

To be able to compare the cross section measurement to the theoretical predictions the experimental result has to be given as function of the **true** electron momentum (pT)

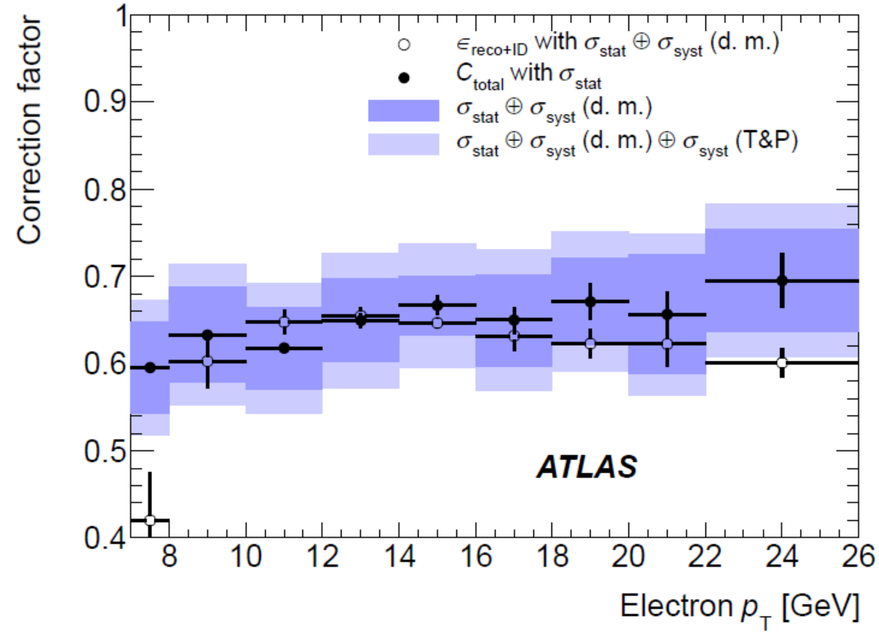
$$\frac{C_{\rm migration}}{\epsilon_{\rm reco+ID}}$$

The ***unfolding bin-by-bin procedure*** allows to deconvolve the detectors' resolution effects.

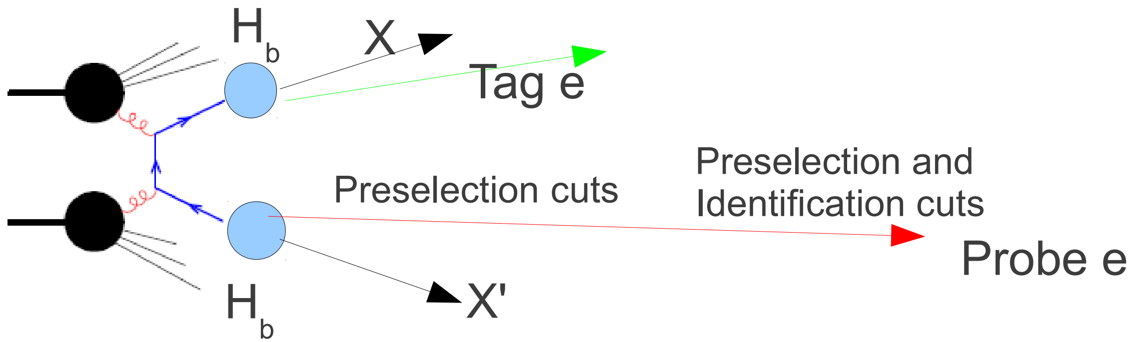
- Estimation of a correction factor ($C_{\rm migration}$) to account the bin to bin electrons migration
  (reconstructed e_T *Vs* truth p_T)

- Estimation of the correct efficiency:

$$\boxed{C_{\rm total} = \epsilon_{\rm reco+ID}/C_{\rm migration}}$$



Signal identification efficiency using T&P



$$\epsilon_{\mathrm{ID}}^{\mathrm{T\&P}} = \frac{N_{\mathrm{probe\ \&\ identified}}^{Q\rightarrow e}}{N_{\mathrm{probe}}^{Q\rightarrow e}}$$

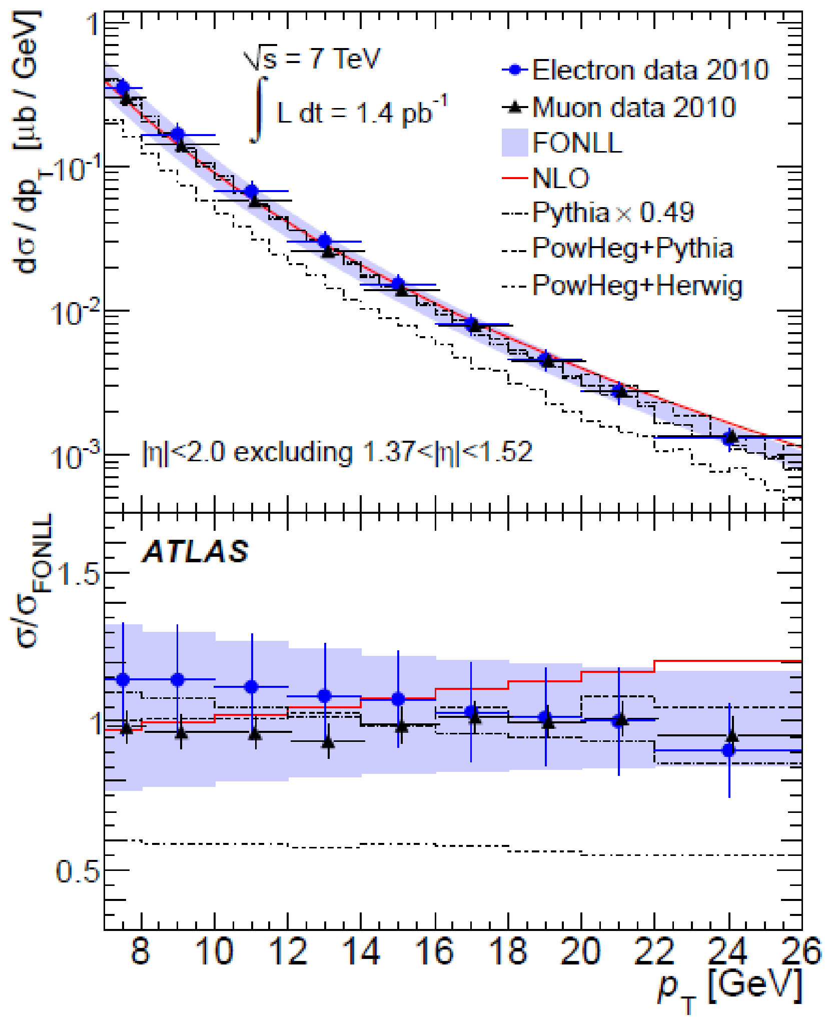
- A tight selection is applied to the tag electron, allowing to enrich the probe sample with signal electrons
- On the probe side the signal selection criteria are applied and the efficiency is measured

	probe electron	probe & identified electrons
Misidentified hadrons (%)	73.7	49.3
Electrons from conversions (%)	17.3	19.5
Signal electrons (%)	9.0	31.2

The signal component is still dominated by the background sources even if the T&P technique is applied

The $\sigma_{b \to e,\mu}$ measurement

Electron and muon differential cross section



The $\sigma_{X \rightarrow \mu}$ measurement

Inclusive differential muon production cross section